REPORT DOCUMENTATION PAGE

AFRL-SR-AR-TR-03-

0289

1. REPORT DATE *(DD-MM-YYYY)* 01-07-2003	**2. REPORT TYPE** Final Technical	**3. DATES COVERED** *(From - To)* 01062002 - 31052003
4. TITLE AND SUBTITLE (U) (DURIP02) Portable Diode Laser Diagnostic System for Collaborative Research on Air-Breathing Combustion		**5a. CONTRACT NUMBER**
		5b. GRANT NUMBER F49620-02-1-0286
		5c. PROGRAM ELEMENT NUMBER 61103D
6. AUTHOR(S) Ronald K. Hanson		**5d. PROJECT NUMBER** 3484
		5e. TASK NUMBER US
		5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Department of Mechanical Engineering Stanford University Stanford CA 94305-3030		**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) AFOSR/NA 4015 Wilson Boulevard Room 713 Arlington VA 22203-1954		**10. SPONSOR/MONITOR'S ACRONYM(S)**
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited

20030822 141

13. SUPPLEMENTARY NOTES

14. ABSTRACT

This equipment grant focused on four areas: (1) portable diode laser sensors with new fiber-coupled diode lasers and the support equipment to provide higher power with extended wavelength tuning range and speed; (2) agile wavelength tuning to cover a broader wavelength region; (3) new wavelength sources for the ultraviolet to expand the wavelengths available for sensor strategy research; and (4) portable data acquisition and laser control electronics.

15. SUBJECT TERMS

diode laser spectroscopy, combustion

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON** Julian M. Tishkoff
a. REPORT Unclassified	**b. ABSTRACT** Unclassified	**c. THIS PAGE** Unclassified	UL	5	**19b. TELEPHONE NUMBER** *(include area code)* (703)696-8478

RECEIVED JUL 0 9 2003

Final Technical Report

Portable Diode Laser Diagnostic System for Collaborative Research on Air-breathing Combustion

AFOSR Grant F49620-02-1-0286

Prepared for

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH

For the Period

June 1, 2002 to May 31, 2002

July 1, 2003

Submitted by

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Portable Diode Laser Diagnostic System for Collaborative Research on Air-breathing Combustion

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EQUIPMENT ACQUIRED

Table 1 lists the equipment purchased by the DURIP Grant, Portable Diode Laser Diagnostic System for Collaborative Research on Air-breathing Combustion, AFOSR Grant F49620-02-1-0286 and matching funds from Stanford University Cost Sharing Accounts. This contract covered the period June 1, 2002 to May 31, 2002.

RESEARCH SUMMARY

Laser-based diagnostics measurements have enabled extraordinary advances in our understanding of the reactive flows during the past two decades. This understanding has led to the design and testing of new propulsion and aero-engine concepts. Modern propulsion test facilities are now commonly equipped with laser-based tools for flow visualization, spray characterization, and planar laser-induced fluorescence measurements of temperature, fuel mixing, and combustion intermediate species.

The development of inexpensive, rugged, solid-state laser sources by the telecommunications industry has led to a new revolution in practical and portable sensors for high-speed reacting flows. Simultaneous multi-parameter measurements using diode laser-based sensors now offer prospects for real-time combustion control. This equipment grant has provided equipment enabling research on portable sensors based on multiplexed telecommunications diode lasers. In addition, this grant provided equipment to extend the available wavelengths in the infrared and ultraviolet.

This equipment grant was focused on four areas: 1) portable diode laser sensors with new fiber-coupled diode lasers and the support equipment to provide higher power with extended wavelength tuning range and speed, 2) agile wavelength tuning to cover a broader wavelength region, 3) new wavelength sources for the ultraviolet to expand the wavelengths available for sensor strategy research, and 4) portable data acquisition and laser control electronics. The equipment list in Table 1 shows the distribution of expenses in these three focus areas.

This new equipment has allowed important expansion of our current studies. In particular, the portable diode laser sensor system assembled using this new equipment was used for experiments at Wright-Patterson AFB. Figure 1 illustrates the sensor used in the gas turbine combustor sector test rig to measure gas temperature using water vapor

absorption. Figure 2 shows the first-ever diode laser absorption measurements inside a gas turbine combustor sector; in this case of water vapor concentration and temperature.

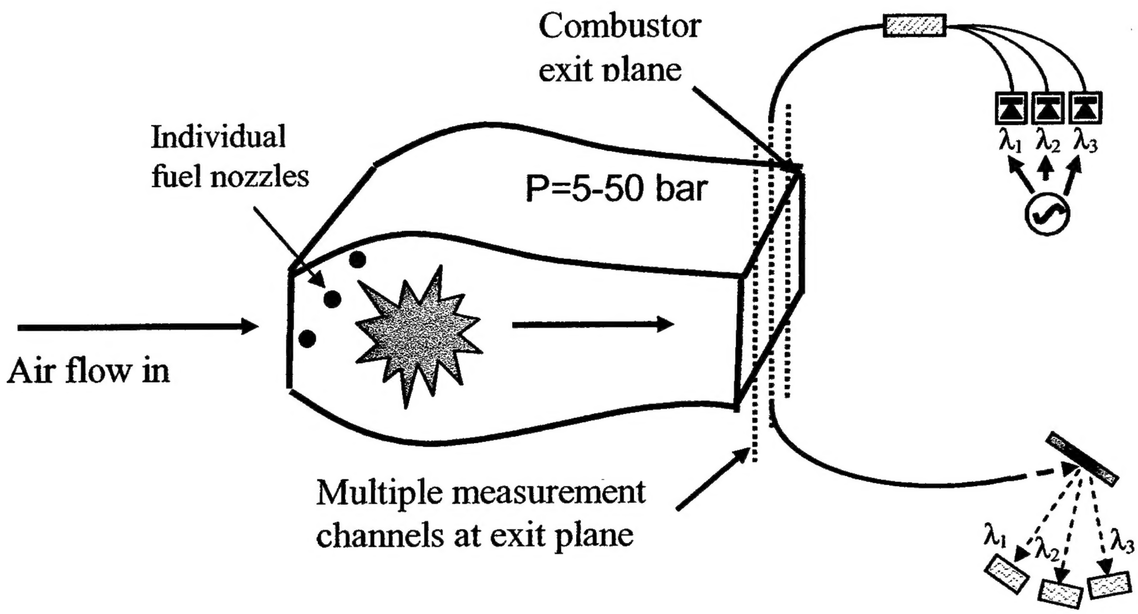

Figure 1. Multiplexed diode laser sensor used to measure water vapor absorption in a gas turbine combustor sector test rig at WPAFB.

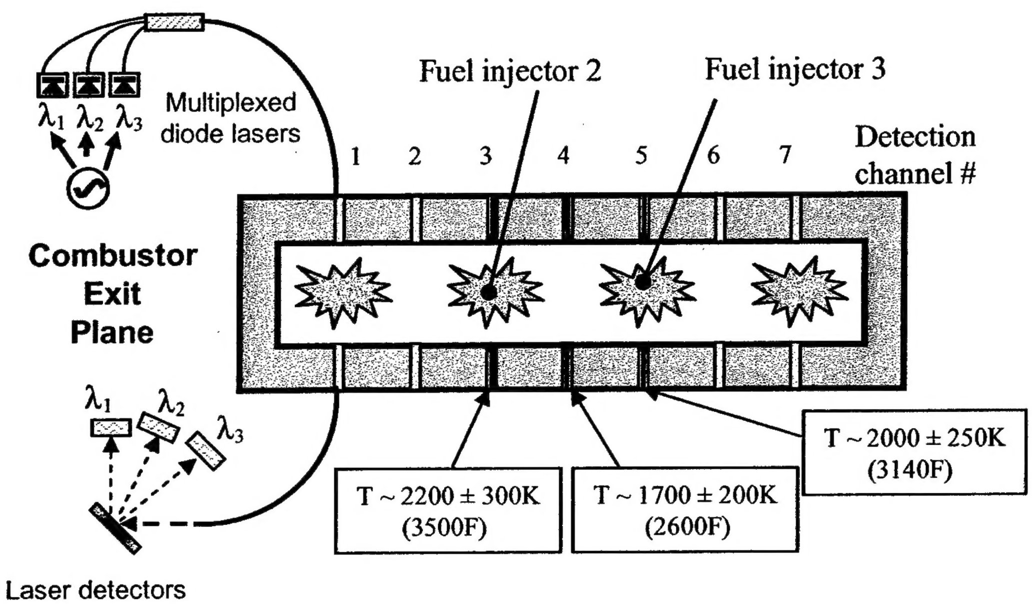

Figure 2. Temperature measured by the diode laser sensor varies with position with respect to the fuel injectors in the gas turbine combustor sector.

A similar experimental arrangement was also successful to measure time-resolved temperature in the scramjet combustor test rig at Wright-Patterson AFB. The collaboration with the scramjet team is continuing, and we anticipate additional measurement campaigns in the future.

We recently developed a new approach to UV absorption-based temperature sensing based on our recent discovery of strong temperature dependence in the CO_2 absorption cross-section. Initial tests of this strategy in the Stanford PDE are extremely encouraging; these measurements were enabled by the new high-power VUV lamp purchased on this equipment grant. Most recently the new cw 266 nm laser source funded by this grant was used to investigate absorption in shock-heated flows. The initial measurements are also quite encouraging; this source may prove a robust tool for routine absorption measurements in combustion flows.

Finally, the fabrication of a new spectroscopic data validation facility consisting of a new three-zone oven and test cells with gas mixture and pressure control is nearing completion. This facility will enable us to investigate the high temperature and elevated pressure spectroscopy needed to develop practical optical sensors to combustion and propulsion flows and provide controlled test conditions.

TABLE 1: Portable Diode Laser Diagnostic System for Collaborative Research on Air-breathing Combustion (Fabrication)

ExpenditureFabrication	*Cost ($)*
Portable IR Laser Sensors	**51,700**
Agile Wavelength Tuning	**97,400**
Expanded Wavelength Range-UV	**57,500**
Portable Data Acquisition	**29,900**
TOTAL	**$236,500**
Stanford University Contribution (10%)	**$ 23,650**
Total AFOSR funds	**$212,850**